Project Report: Microbial Fossilization Processes in Extreme Environments

Lead Team:	***Arizona State University***
Project Title:	***Microbial Fossilization Processes in Extreme Environments***
Project Investigator:	***Jack Farmer***

Project Progress

1. To better understand the preservation of microbial biosignatures in hydrothermal settings, I have traced the fate of epiphytic diatoms entombed in travertine spherulites. These structures are pervasively formed in distal, low temperature environments around modern hot spring outflows at Angel Terrace (Mammoth Springs, Yellowstone) and Thermopolis (southern Wyoming). The diatoms in these modern systems consist of pennate skeletons (frustrules) of opaline silica. Qualitative electron microprobe analysis of the diatoms entombed in modern speherulites showed them to contain concentrations of molybdenum, compared to the entombing carbonate matrix. For comparison, similar Pleistocene−aged spherulitic travertines were collected from quarries at Gardiner, Montana, and in the Cuatro Cienegas Basin (Central Mexico). These travertines had undergone substantial post−burial recrystallization and cementation. Small silica grains discovered by electron microprobe mapping were easily missed in a precursor thin section analysis, but electron microprobe mapping of polished thin sections revealed the presence of small patchy domains of silica within spherulites. Silica patches retained the basic size and shape of diatoms, but were composed of quartz, the stable low−temperature silica phase. Electron microprobe mapping failed to reveal evidence for carbon or trace metal signatures. However, the electron microprobe is typically not sensitive enough for quantitative trace element analysis. Therefore, the next steps in this study are to 1) examine silica patches for evidence of trace element enrichments using more sensitive methods of X−ray (Synchotron) tomography and 2) use ion microprobe analysis to look for evidence of biological fractionation in silicon isotopes.
2. In collaboration with the Ecogenomics Focus Group, I continued

my previous studies of laminated fabrics in submerged, cyanobacterial mats of shallow saltern environments of Guerrero Negro, Baja Sur, Mexico. This involved the collection and field fixation of mat materials from the newly designated Ecogenomics Focus Group study sites, followed by a lab characterization of preserved mat materials by electron, dual interference contrast and flourescence microscopy of large format thin sections. Section preparation required perfecting a new embedding method for exopolymer−rich mats using low viscosity resins. Microfabric studies have now been completed and a draft manuscript is in preparation.

3. This past year, as part of the Ecogenomics Focus Group project, we also began a systematic study of meiofaunal grazers (primarily nematode species) associated with the Microcoeleus mats at Guerrero Negro. The meiofauna of laminated mats provides a potential ecological analog for early metazoan evolution. We have been documenting the patterns of meiofaunal migration during a diel experiment where we also monitored changes in oxygen, sulfide, and pH during a daily cycle of photosynthesis. This year we also began documenting the trophic interactions of meiofaunal species using dual interference microscopy to identify gut contents. Next we will isolate meiofaunal species from Microcoeleus mats to identify morphospecies using a scanning electron micrograph (SEM). Isolates of living nematode species will be cultured to obtain pure isolates of morphospecies for molecular sequencing and phylogenetic analysis.

Highlights

- Microbial mats of hypersaline marine lagoons, Baja Sur, Mexico, provide a natural lab for understanding the ecological and evolutionary context of early animal evolution.

- Tiny silica−secreting plants entombed by hot−spring carbonates leave behind long−lasting mineral biosignatures in ancient deposits.

Roadmap Objectives

- ***Objective No. 6:*** Microbial Ecology
- ***Objective No. 7:*** Extremes of Life
- ***Objective No. 8:*** Past Present Life on Mars

Field Expeditions

Field Trip Name: Ecogenomics Focus Group	
Start Date: 05/01/2001	***End Date:*** 05/31/2001
Continent: North America	***Country:*** Mexico
State/Province: Baja, Sur	***Nearest City/Town:*** Guerrero Negro

Latitude:	***Longitude:***
Name of site(cave, mine, e.g.): Exportadora De Sol saltern and adjacent margins of Laguna Ojo De Liebre	***Keywords:*** Baja Sur, Microbial Mats, Biosedimentology, Meiofauna, Grazers
Description of Work: Studies of biosedimentar structures and fabrics of 1) Submerged, laminated microbial mat ecosystems of saltern environments (Ponds 4 and 5) owned and operated by Exportadora de Sol and 2) Supratidal mats living in natural lagoon areas adjacent to Pond 7. Environmental monitoring, temporal and spatial distribution of mat types (surface structures and microfabrics), overall biosedimentological context of mat development and preservation, ecological contributions of grazing meiofauna and impacts of grazing on the environmental distribution of mats and their physical and ecological structure.	
Members Involved: Jack Farmer, Ferran Garcia−Pichel, Brad Bebout, Dave Des Marais.	

Cross Team Collaborations

I have interacted with the microbial mat group at NASA Ames (Brad Bebout, Dave Des Marais), Ferran Garcia Pichel at ASU, and to a limited extent, Norm Pace and his group at the Univ. of Colorado. These interactions included joint field work and support, obtaining research permits, sharing sampling protocols, and adding data to a web archive and participating in telecon team meetings.